

Neurosurgical Management of Self-Inflicted Cranial Crossbow Injury

Charles G. Kulwin, MD, Andrew DeNardo, MD, Saad Khairi, MD, and Troy Payner, MD

Department of Neurological Surgery, Indiana University School of Medicine and Goodman Campbell Brain and Spine, Indianapolis, Indiana

Author emails:

ckulwin@goodmancampbell.com

adenardo@goodmancampbell.com

skhairi@goodmancampbell.com

tpayner@goodmancampbell.com

Corresponding Author:

Charles Kulwin, MD
Department of Neurological Surgery
Indiana University School of Medicine
Goodman Campbell Brain and Spine
355 W. 16th St, Suite 5100
Indianapolis, IN 46202
Phone: 317-396-1357
Fax: 317-957-0034

Financial and Funding Disclosures: NONE

This is the author's manuscript of the article published in final edited form as:

Kulwin, C. G., DeNardo, A., Khairi, S., & Payner, T. (2018). Neurosurgical Management of Self-Inflicted Cranial Crossbow Injury. *World Neurosurgery*, 116, 69–71. <https://doi.org/10.1016/j.wneu.2018.05.048>

Abstract:

Background: While gun-related penetrating traumatic brain injuries make up the majority of cranial missile injuries, low-velocity penetrating injuries present significant clinical difficulties that cannot necessarily be identically managed. Bow hunting is an increasingly popular pastime, and a crossbow allows a unique mechanism to cause a self-inflicted cranial injury with a large, low-velocity projectile. Historically, arrow removal is described in an operating room setting, which provides limited knowledge of the location of vascular injury in the setting of post-removal hemorrhage, and may represent an inefficient use of operating room availability.

Case Description: Two patients presented after self-inflicted cranial crossbow injuries. Both were neurologically salvageable. Initial assessment with CTA allowed triage into likely or unlikely vascular injury. Arrow removal was performed in a radiology setting rather than in the operating room to allow immediate post-removal imaging to localize hemorrhage. While an operating room was on standby, neither patient required neurosurgical operative intervention. Both patients made a good recovery with no further injury caused by arrow removal.

Conclusions: We describe a novel approach to retained cranial arrow removal in a radiologic, rather than operative setting, and describe its relative benefits over traditional removal in the operating room.

Key words: Penetrating brain injury, traumatic brain injury, crossbow, bolt, arrow, self-inflicted

Running title: Cranial crossbow injuries

Introduction

Penetrating traumatic brain injuries (TBI) to the head are classified as missile and nonmissile injuries. The majority of missile TBIs are gun-related, and are well described in the literature. Crossbows represent a unique hybrid injury as a low-velocity missile that creates an injury similar to nonmissile injuries but in a ballistic fashion—with the ability to self-inflict injury similar to a firearm. The 21st century has seen a steady increase in bowhunting license sales¹. Crossbow injuries also result in a much larger retained foreign body than more traditional gun injuries. The majority of low velocity missile and non-missile TBIs in the literature undergo foreign body removal in an operating room setting^{2,4,5}. In this technical study we describe our approach for foreign body removal in a radiological setting in two patients with self-inflicted crossbow injuries, and discuss the rationale and benefits of this approach over direct removal in the operating room.

Case Reports

The first patient presented after a self-inflicted crossbow injury to the orbit. His presenting exam was grossly nonfocal aside from his orbital injury, but due to mental status decline he was subsequently intubated; he continued to follow commands after intubation. Imaging (Fig 1A) revealed a metal-tipped, carbon-shaft arrow entering near the optic foramen and imbedded in the occipital bone. Careful examination of the imaging and identification of a similar crossbow arrow provided by family revealed a smooth, tapered tip with no barbs or flanges relative to the shaft. CT angiography (Fig 1B) revealed that no major vascular injury had occurred, although the shaft passed near the internal carotid artery and the transverse sinus appeared to be occluded. The patient was taken to the CT suite and an operating room was put on notice for possible emergent craniotomy. The arrow was removed manually with very little resistance with the patient on the CT scanner bed. Immediate CT imaging of the head was obtained that showed no new hematoma along the arrow trajectory (Fig 1C). A single suture was placed in the skin at the entry point. The patient's neurologic exam remained unchanged and he was moved to the ICU for further observation. Follow-up CTA showed no vascular injury and no pseudoaneurysm development. Patient was subsequently discharged after a short hospital stay with no further neurosurgical events.

The second patient presented after a self-inflicted submental injury, with complete transfixion of the head, exiting just above and lateral to theinion. An emergent cricoid airway was placed in the field due to oropharyngeal injury; he continued to follow commands in all extremities. The arrow's head was removed sharply in the field prior to arrival. CT imaging (Fig 2A) revealed an intact carbon shaft traversing the inferior

oropharynx, passing between the dens and the lateral mass of the C1 vertebra, passing through the cerebellar peduncle, the falx, and the occipital lobe. CT angiography revealed that there was no vascular injury to the carotid vessels or dural venous sinuses, but that the arrow passed between the cervicomedullary junction and the vertebral artery with significant compression of the vertebral artery (Fig 2B). The patient was taken to the angiography suite and an operating room was put on notice for possible emergent craniotomy. A diagnostic cerebral angiogram was performed, revealing significant displacement and stenosis of the vertebral artery by the shaft of the arrow (Fig 2C). The contralateral vertebral artery was large and patent. The involved vessel was then occluded proximal and distal to the shaft with endovascular coil embolization (Fig 2D). The arrow could not be easily pulled out so it was removed using manual traction and mallet percussion for disimpaction. Repeat six-vessel cerebral angiography was immediately performed, demonstrating no active extravasation. The exit site was irrigated and closed with a skin stapler. The entry site was dressed. The patient was taken to the ICU, and a follow-up head CT showed no new hemorrhage. His neurologic exam remained unchanged. The patient was later taken to the OR by ENT for conversion of his emergent airway to a tracheostomy and entry wound debridement and closure. He was subsequently discharged after a short hospital stay.

Discussion

The few case reports of neurosurgical removal of cranial crossbow arrows and similar low-velocity large missile injuries describe removal in the operating room. The presumed reason was for hemostasis and wound debridement and closure. For gunshot injuries this rationale is sensible: the foreign body is small and if removed, new hemorrhage would be localized to the region of the bullet. Also, there is often devitalized tissue near the entry and/or exit wounds requiring more complex debridement and closure. This approach does not apply to large, low-velocity missiles such as crossbow arrows for a number of reasons.

First, the foreign body is large; therefore, removal is necessary unlike a small, deep bullet fragment. Second, the act of removal may release or cause hemorrhage at any point along the long course of the foreign body. Intraoperative exposure of the entire object is not feasible. Therefore, if removed in the operating room, subsequent hemorrhage from an entry or exit site can be very difficult to localize given the long trajectory of the object involving multiple anatomic compartments. Removal in a radiology setting allows prompt localization of any hemorrhage. We have applied a treatment algorithm in these two patients, as well as other similar patients over the last 20 years, with large penetrating foreign bodies without large intracranial hemorrhages. Based on CT angiography, in the presence of overt large vessel involvement, an angiogram is performed. If an injured vessel is identified or suspicion is high that removal of the foreign body will cause arterial hemorrhage, then the vessel is

preemptively sacrificed as long as there is adequate collateral. The object is then removed and immediate repeat angiography is performed that allows treatment of any new active hemorrhage. If none is seen, the patient returns to the ICU and a short-term CT is performed to look for a new hematoma from smaller vessel hemorrhage. In the absence of overt vascular involvement, the object is removed with the patient in the CT scanner and an immediate post-removal scan is obtained. In either case, if a large hematoma is seen, the patient can be promptly taken to the OR, which is notified in advance to prepare for emergency craniotomy, and the hematoma can be addressed with the important benefit of knowing the location of the hematoma along the missile's trajectory rather than blindly pursuing hemostasis without knowing the location of the source. If there is no hematoma immediately after removal, an early repeat CT is performed within a few hours or sooner if there is any sign of neurologic decline.

Third, arrows tend to cause small skin injuries with healthy edges, without the macerated tissue often seen in gunshot injuries, that can be debrided and closed at bedside in accordance with penetrating brain injury guidelines.³ This approach allows both more targeted surgeries for bleeding/hematoma than up front removal in the operating room, as well as avoiding unnecessary operating room procedures in this population. We propose that initial treatment of arrows and similar low-velocity large retained missiles without operative hematoma occurs in a radiologic setting, rather than an operative setting, due to improved patient safety, efficiency of resource utilization, and optimizing healthcare costs.

Conclusions

We describe two cases of cranial crossbow arrow injuries, managed in a novel fashion: removal in a radiologic setting, rather than in the operating room. We discuss the rationale for this approach, a simple treatment algorithm, and discuss the advantages over traditional operating room removal including prompt localization of post-removal hemorrhage, increased patient safety and increased healthcare resource efficiency.

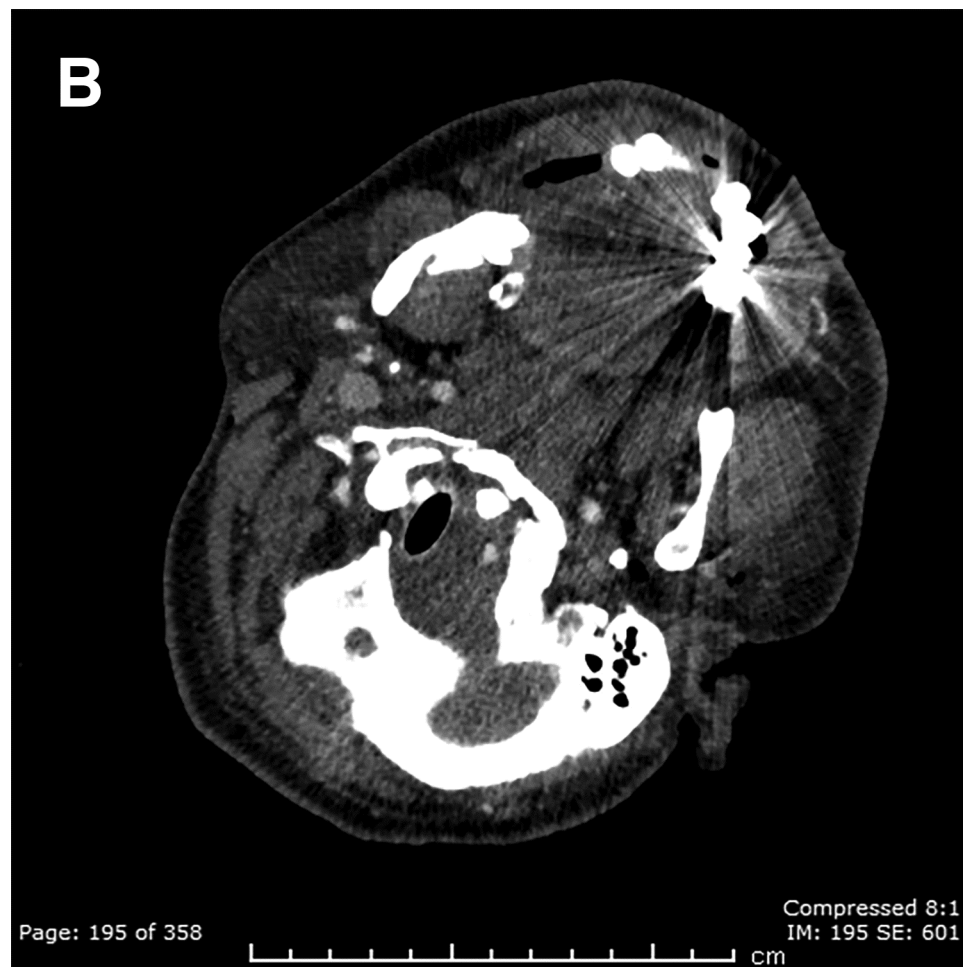
REFERENCES

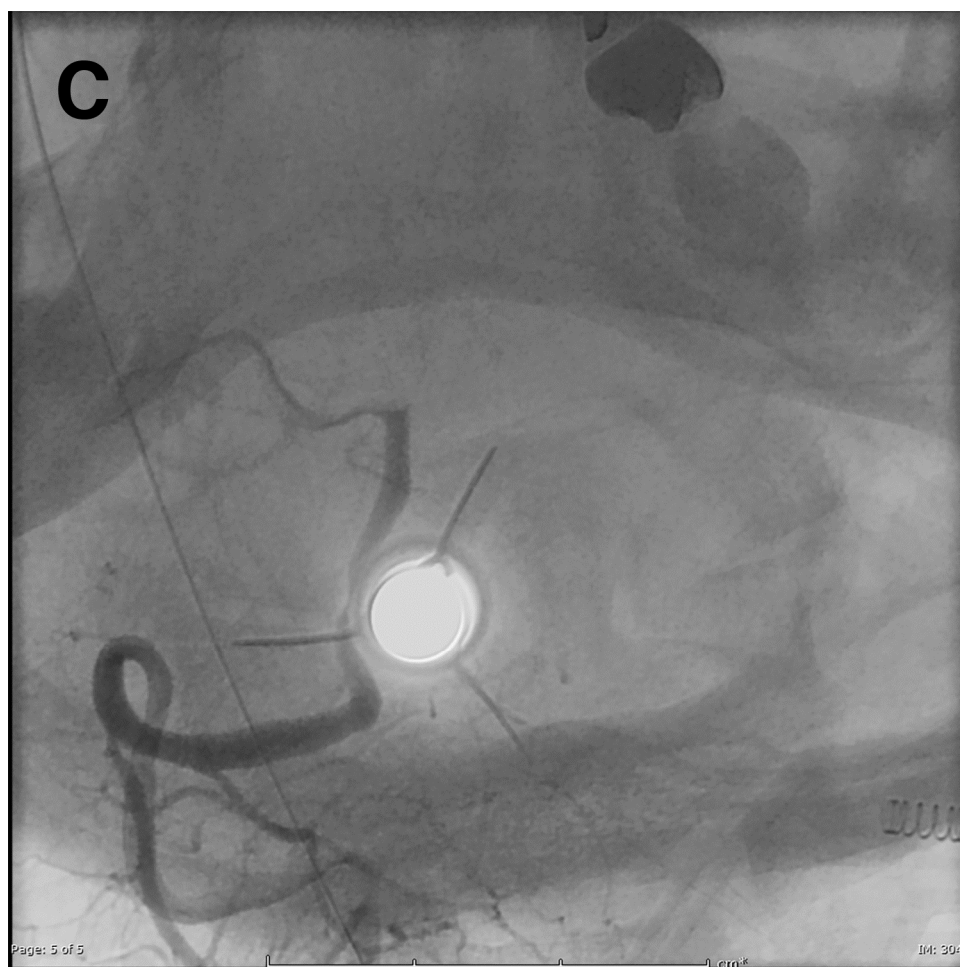
1. U.S. Bowhunter Numbers See Record Increase. *Archery Business.*: 12-13, 2011.
2. Kaye K, Kilgore KP, Grorud C. Transoral crossbow injury: an unusual case of central nervous system foreign body. *J Trauma* 57:653-655, 2004.
3. Kazim SF, Shamim MS, Tahir MZ, Enam SA, Waheed S: Management of penetrating brain injury. *J Emerg Trauma Shock* 4:395-402, 2011.
4. Mzimhiri JM, Li J, Bajawi MA, Lan S, Chen F, Liu J. Orbitocranial low-velocity penetrating injury: a personal experience, case series, review of the literature, and proposed management plan. *World Neurosurg* 87:26-34, 2016.
5. Xiao J, Bennett GJ, Lutske ME, Belles WJ, Guo WA. Oral, maxillary, and cranial impalement injury by a crossbow arrow. *Surgery* 159:1234-1235, 2016.

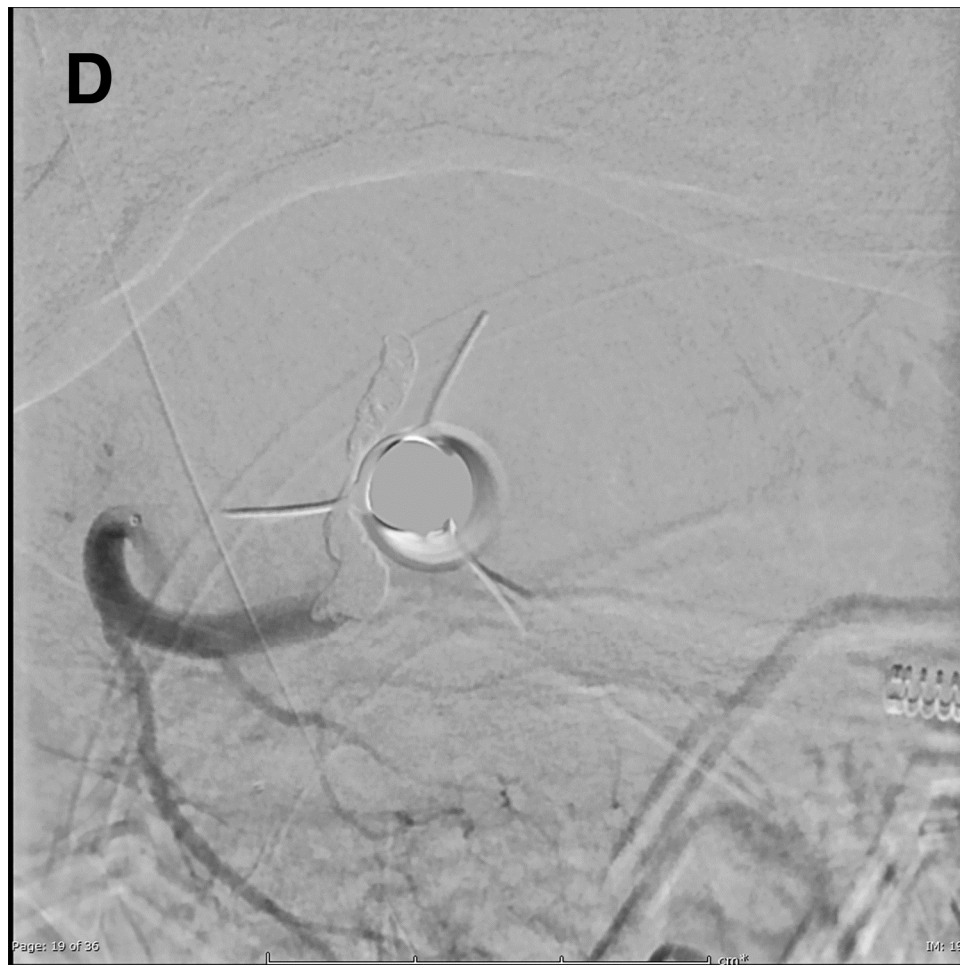
FIGURE LEGENDS

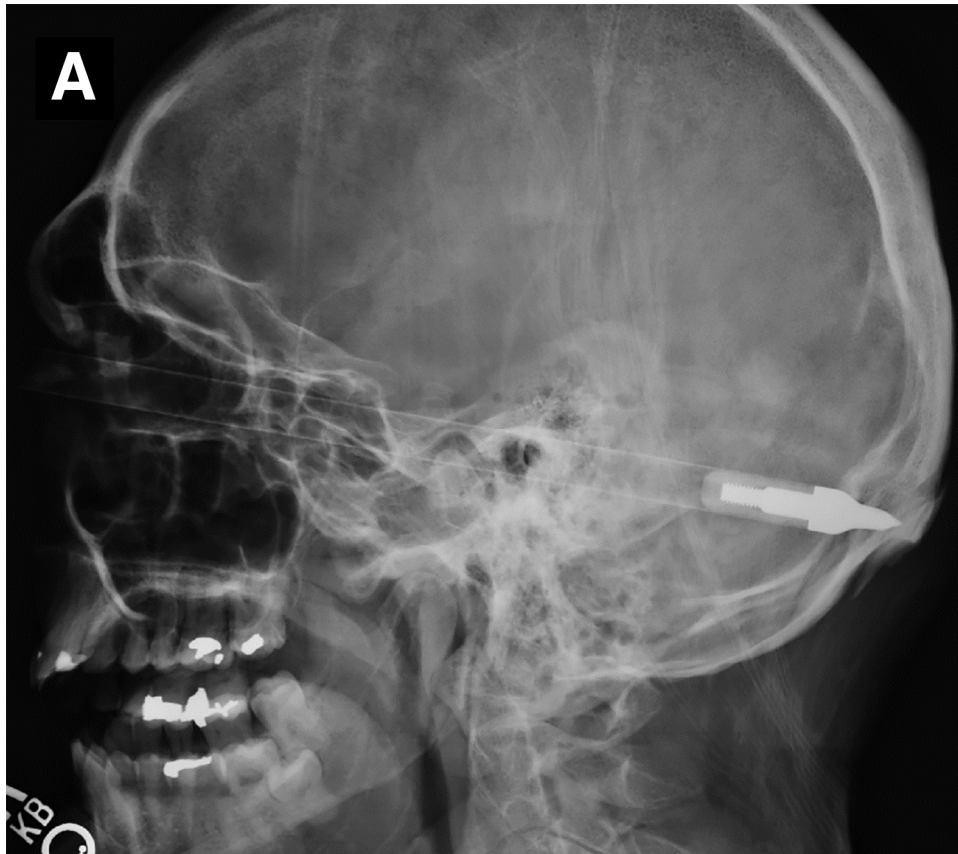
Figure 1: Patient One. A: Lateral skull plain film demonstrating transcranial arrow and configuration of arrowhead. Notice lack of barbs or flanges from shaft edge to tip. B: Coronal CT angiogram showing arrow trajectory through mesial temporal lobe, avoiding injury or contact with any major vascular structures. C: Axial CT showing post-removal trajectory with no new or large hematoma.

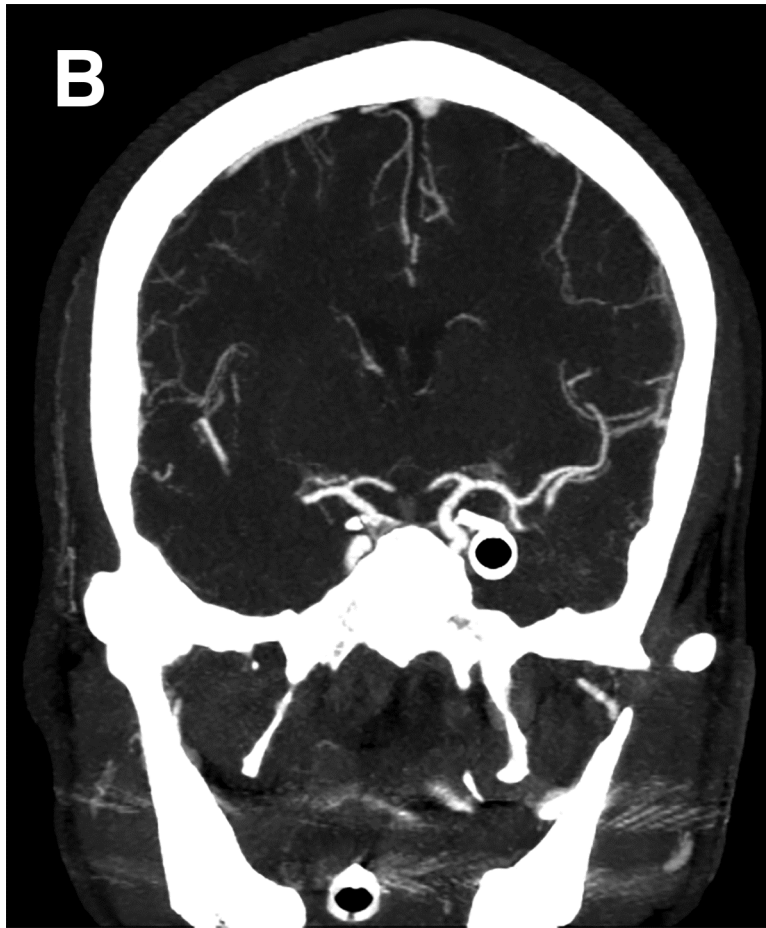
Figure 2: Patient Two. A: Lateral scout CT image showing trajectory of the arrow (hypodense linear structure, arrows). B: Axial CT angiogram showing shaft (arrow) trajectory between the odontoid tip and lateral mass of C1, then between the vertebral artery and the brainstem. C: Digital subtraction angiogram down the shaft of the arrow showing displacement and traumatic stenosis of the vertebral artery. D: Post-coil embolization digital subtraction angiogram down the shaft of the arrow showing complete occlusion proximal and distal to the site of suspected arterial injury.



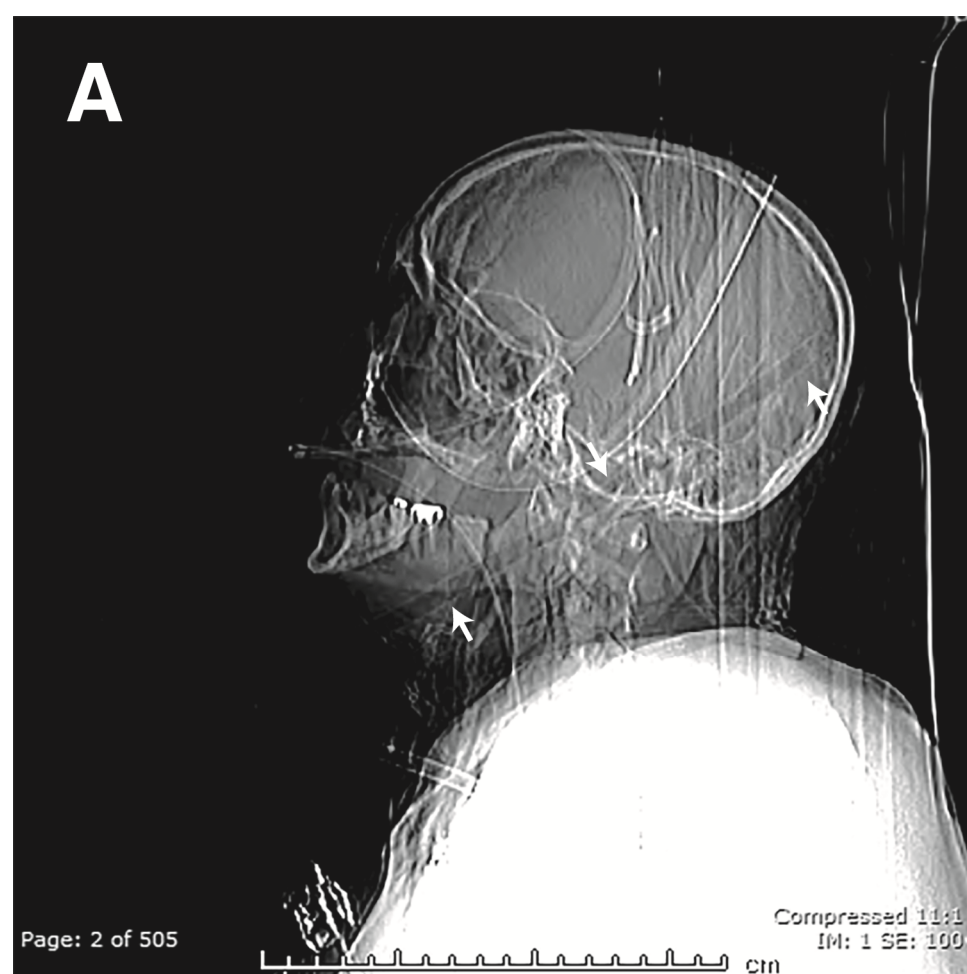












Highlights

- Two cases of cranial crossbow injuries managed in a novel fashion.
- Removal done in a radiological setting rather than in the operating room.
- Advantages include increased patient safety and healthcare resource efficiency

ABBREVIATIONS

TBIs = traumatic brain injuries

CT = computed tomography

CTA = computed tomography angiography